Building Decarbonization Alliance
pour la décarbonation des bâtiments

MODERN TECH, MODERN PRACTICES:

UPGRADING HEAT PUMP SIZING GUIDELINES IN CANADA

Heather McDiarmid
Senior Advisor
Building Decarbonization Alliance

Mathieu Lévesque
Technology & Alternatives Lead
Building Decarbonization Alliance

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Authors

Lead Author
Heather McDiarmid
Senior Advisor
Building Decarbonization Alliance
Climate Change Consultant
McDiarmid Climate Consulting

Support from
Mathieu Lévesque
Technology & Alternatives Lead
Building Decarbonization Alliance

About the Building Decarbonization Alliance

The Building Decarbonization Alliance is a non-partisan and cross-sector coalition working to change the narrative on building heat, inspire and inform industry and government leadership, and accelerate market transformation. We reach beyond rhetoric to engage with evidence and science, helping put in place the conditions for effective policy, change the narrative, and increase awareness of the benefits of decarbonized all-electric buildings.

We've convened over 300 Partner organizations. We're working hard to expand the reach of our Alliance and proposing an exciting slate of research and initiatives to advance our mission and vision. If you are interested in supporting our work, visit our website or reach out to us at info@buildingdecarbonization.ca to find out how you can help accelerate building electrification.

Acknowledgment

We would like to thank the half dozen residential heat pump installers who gave their time to answer questions and provide thoughts on the best ways forward for heat pump installations.

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Executive Summary

Heat pumps are an increasingly important solution for improving home comfort, saving energy, and cutting costs while decarbonizing single-family homes in Canada. However, many of the industry practices in use or recommended today rely on old habits which can undermine these outcomes, resulting in reduced energy and emissions savings, higher rates of customer dissatisfaction, and slower heat pump uptake.

Our analysis, based on installer interviews and modelled energy outcomes, finds that conventional heat pump sizing methods—those relying on rules of thumb or model-based heating load estimates—commonly recommend oversized systems which can compromise performance, increase customer dissatisfaction and installer call-backs, and ultimately slow adoption. Furthermore, we found that many installers program hybrid heat pumps too conservatively (i.e., switch to fuelled systems at relatively high temperatures), underutilizing the cleaner, more efficient, and potentially less expensive to operate heat pump. Installers want simple and easy-to-use tools to support good sizing and optimal programming. Natural Resources Canada (NRCan) developed a guide and app to assist installers in sizing heat pumps for both new construction and existing buildings. The methodology in the guide and app is sound, but the modelled heating load estimates installers use as inputs can often lead to oversized units in existing buildings.

We recommend four strategies grounded in modern industry best practices to accelerate the quality installation of heat pumps and maximize their wide-ranging benefits:

1. When possible, heat pumps in existing homes should be sized based on historical heating energy use, and validated tools should be developed to support this.
2. Installers must be engaged when developing sizing and programming tools to ensure they meet installers' needs and to build buy-in for heat pump adoption.
3. Manufacturers should modernize thermostats for hybrid heat pumps, making them easier to program for economic, energy, and emissions savings.
4. Heat pump incentive programs should promote proper sizing and programming.

These measures would ensure that heat pumps fulfill their promise—not only as a climate solution, but as a dependable, comfortable, and cost-effective technology for Canadian homeowners.

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Background

Heat pumps for single-family homes are growing in popularity due to their potential to improve home comfort, reduce operational costs, provide both heating and cooling services, and reduce energy use and emissions. The most common centrally ducted heat pumps exchange heat with the outside air (an air source heat pump, or ASHP) and may be sized to provide all or a portion of the heating load, relying on backup electric resistance heaters or fuelled furnaces (commonly referred to as hybrid heating systems) to make up any shortfall. With hybrid systems, installers must also program when heating should switch from the heat pump to the fuelled system.

Heat pump technology is significantly different from furnaces and boilers. Conventional heating systems have been routinely oversized with minimal impact on function,[1] but the industry practices used for decades for fuel-fired systems do not work well with modern heat pumps, which require more precise sizing to function optimally.

The sizing and programming strategy used when a heat pump is installed strongly affects its performance over its lifetime. Ideally, sizing is based on the heating or cooling load of the home, its location, and existing ductwork capacity, while programming will determine when a heat pump switches to backup heaters to optimize desired outcomes. It is important that we get this right, as poor sizing and programing of heat pumps will harm their reputation and slow their adoption.

Heat pump incentive programs have started to recognize the importance of installation quality and sizing on performance outcomes. Ontario's Home Renovation Savings Program, for example, now requires installers to use Natural Resources Canada's (NRCan) Air-Source Heat Pump Sizing and Selection App, with incentive values based on the size of the heat pump. In 2026, Enbridge's heat pump incentives will be based on the NRCan sizing strategy used.

This analysis explores the potential impacts of currently recommended practices for sizing heat pumps in Canada and makes recommendations to ensure installers are well placed to right-size and install heat pumps to optimize the energy, emissions, and pocketbook impacts of heat pump incentive programs. The work is based on interviews with installers and other experts in the field as well as analysis of heat pump outcomes from modelled heating loads.

1 https://www.nrel.gov/docs/fy02osti/31318.pdf

Conventional heating and cooling systems are commonly oversized

Heating and cooling systems of all types are often intentionally oversized. A US survey revealed that nearly 40% of installers intentionally oversize conventional heating equipment to avoid callbacks, accommodate future additions, and address customer fears of undersizing.[2] EnergyStar reports that installers also oversize air conditioners to ensure faster cooling, often at the expense of efficiency, comfort, humidity control, and other factors.[3]

On top of these factors are the unintended ways in which heating and cooling systems may be oversized. Many heat and cooling load models use conservative assumptions to compensate for unknowns and home assessors may add additional safety factors or overly rely on default values (e.g. for window performance) when entering a home's characteristics in those models.[4]

Customers are accustomed to the impacts of oversizing conventional heating and cooling systems, including reduced efficiency, larger temperature swings within the home, and higher fan speeds, but also rapid heating and cooling when thermostat setpoints are changed. Additionally, since most fuel-fired systems on the market are higher-capacity units, there is little to no price difference when choosing a larger size.

Some in the HVAC field estimate that most residential heating systems are oversized by a factor of 2-4.[5,6]

Models often overestimate heating and cooling loads

Our analysis suggests that heating load estimates from home energy audits and Hot2000 modelling software, which are recommended in NRCan's sizing guide, are often higher than other modelled outcomes for heating loads. Figure 1 shows the average heating loads from homes in each province that underwent home energy audits in 2024 compared to average heating loads for single detached and attached homes from the 2021 Comprehensive Energy Use Database (CEUD), adjusted for heating system efficiency. The higher values seen for home audits relative to CEUD are consistent with the experience of installers that we interviewed who expressed distrust of heating loads from Hot2000 and home energy audits. And even the CEUD data is modelled and therefore may overestimate heating loads.

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2 https://www.nrel.gov/docs/fy02osti/31318.pdf

3 https://www.energystar.gov/ia/home_improvement/home_sealing/RightSized_AirCondFS_2005.pdf

4 https://abodeenergy.com/performing-better-manual-j-load-calculations/?utm_source=chatgpt.com

5 https://www.greenbuildingadvisor.com/article/replacing-a-furnace-or-boiler?

6 Tozer, D. (2025) Feel-good homes. ReThink Press https://rethinkpress.com/books/feel-good-homes/

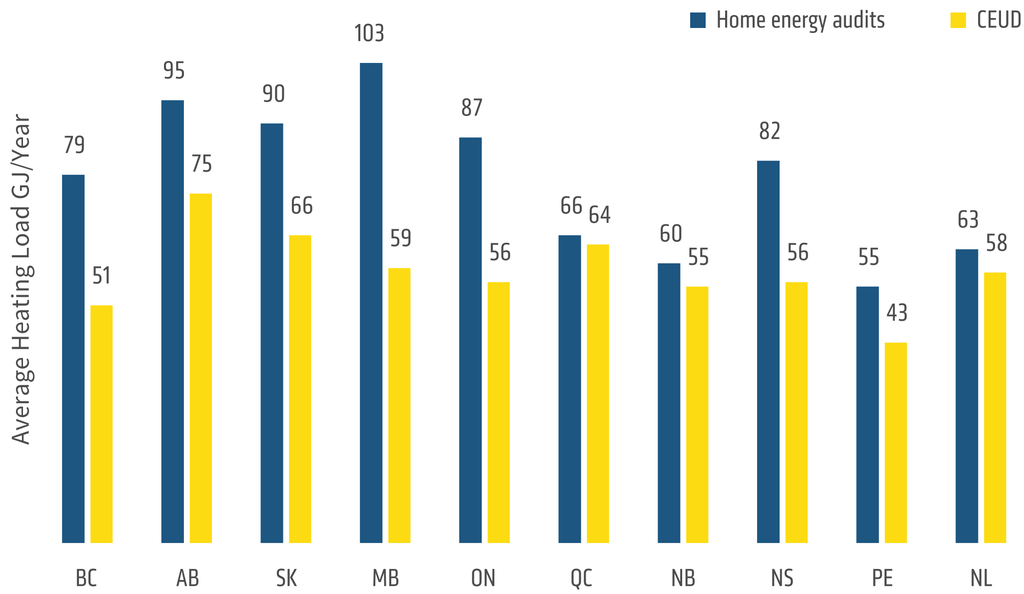

Figure 1: Estimated heating loads by province show a trend of home energy audits being greater than those from the Comprehensive Energy Use Database (CEUD).

While we could find no comprehensive datasets that would allow us to compare modelled heating loads with actual energy use, the following case study points to the potential for home energy audits and Hot2000 to significantly overestimate heating loads. Based on our discussions with installers, this case study is more representative of the norm, and not an exception.

Case study

Built in 1910, this 1900 sq ft semi-detached home in Toronto underwent a home energy audit in 2022 to qualify for a Greener Homes Grant to install a heat pump.

> The home energy audit estimates were 2.4 times greater than actual energy use.

The home audit noted a double brick wall with no added insulation, no insulation on foundation walls, R 1.7 along the flat and cathedral roofs, plus 11.16 air changes per hour at 50 kPa. The annual rated energy consumption for space heating and water heating plus clothes drying was 151 GJ/yr (4,066 m3 natural gas; note that the majority of this would be for space heating). Actual natural gas consumption for space heating, water heating plus clothes drying from Oct 2021 to Sep 2022 was 62.9 GJ/yr (or 1,694 m3). Sizing a heat pump based solely on the audit data would have resulted in a heat pump more than twice as large as needed.

How heat pump systems are sized today

Experienced installers note that the industry commonly uses rules of thumb (e.g., 800 sqft/ ton) and existing heating system capacities for sizing heat pumps, just as they do with conventional heating and cooling systems. Rules of thumb are also commonly used to estimate the outdoor temperature at which a hybrid heat pump should switch from heating with a heat pump to using a fuelled system. Rules of thumb may be based on square footage, home type (e.g., detached versus row housing), the age of the home, and/or rely on the capacities of existing heating and cooling systems.

Modern heat pumps, however, are a more advanced technology that requires new best practices for more precise sizing.

To support better sizing, NRCan released its heat pump sizing guide in 2020. The guide and supporting app help users to size heat pumps using four sizing options. The methodology in the guide and app is sound. However, the recommended inputs for the calculations are only based on *modelled* heating and cooling loads, thus the quality of the outcomes are dependent on the quality of the modelled data.

Concerns raised by installers for retrofit applications include:

- Lack of trust in the modelled heating and cooling load data the sizing guide uses as input,
- Using modelling software to estimate heating and cooling loads is too complex and time-consuming, and
- The sizing guide app can be gamed by entering modelling data input that yields the desired outcome, like most tools mandated through incentive programs without compliance verifications; using historical energy as the input would make them easier to independently verify.

Risks from improperly sizing heat pumps

Unlike fuel-fired systems which turn on and off frequently, heat pumps are designed to provide slow and steady heating or cooling. Ideally, a heat pump's output per hour at a given temperature will closely match the home's heat loss per hour at that temperature by varying the speed of the compressor. Yet since there are upper and lower limits to the heating or cooling output of a heat pump at any given temperature, improperly sizing a heat pump risks impacting its performance.

The downsides of an oversized heat pump are much more significant than the downsides of an oversized fossil fuel furnace.

Risks of an undersized heat pump	Risks of an oversized heat pump
• Increased reliance on backup heating systems can reduce comfort and increase bills, energy, and emissions. • Without a backup: Might not maintain indoor temperature on very cold days, reducing home comfort and causing installer callbacks.	• Insufficient humidity control in summer as the heat pump does not run enough to reach dehumidification conditions. Higher humidity means less comfort and higher risk of mold and other indoor air quality issues. • Short cycling where the heat pump frequently comes on for brief periods. This causes temperature swings, reduces efficiency, can interfere with effective defrosting, and shortens the lifespan of the system. • Noisy operations and reduced efficiency when the heat pump is oversized for the existing ductwork because heat pumps must move a larger volume of air than conventional heating systems to achieve the same heat output. • Unnecessarily high upfront costs because: » Larger units are more expensive; » Larger units are more likely to trigger the need for an electrical panel upgrade; and » Larger units are more likely to require upgrades to the ductwork.

Although heat pumps are a well-established technology, their use for home heating is new to many homeowners. **Poorly sizing heat pumps risks slowing their adoption due to customer dissatisfaction with discomfort, higher costs, and early equipment failure.**

How to properly size heat pumps, according to industry leaders

Guessing or estimating home energy performance using rules of thumb or complex models is often unnecessary because data on the true energy performance of the home is readily available through historical energy bills.

A home's historical energy use is the fastest and most accurate way to *empirically* estimate heating loads. Moreover, it is easier than ever to use historical weather data to adjust historical energy use to account for year-to-year variations in weather. Non-heating or cooling energy loads like hot water and home appliances can be accounted for using seasonal energy use patterns. It is telling that the most reputable and experienced heat pump installers all recommend using historical energy use for sizing, in addition to assessing the existing ductwork's airflow capacity. Installers who also have experience as energy advisors were notably distrustful of models, preferring to use historical energy use alone or in combination with models for sizing. Simple Canadian-made tools are now available to help installers estimate heating loads from gas usage (e.g., Know Your Load). Even these simple tools can be improved by estimating gas usage for other appliances from summer consumption and by using recorded heating degree days to normalize historical energy use. And while some concerns were raised about historical *energy* consumption's ability to accurately estimate *peak* loads, experienced designers in the U.S. and Canada had firsthand experience of success.

When available, recorded data from smart thermostats can provide the most accurate practical estimate of actual peak loads because they reflect real-world performance under peak conditions. Looking at a very cold day, if installed equipment only runs for 30 minutes per hour, that usually means the equipment is about double the required size. Properly trained AI may be able to do this estimation quickly and accurately. Some modern thermostats record this data today—including indoor temperature variations and setpoints—but it is typically hard to access and is not stored long term. Even so, this method could be the benchmark against which other estimates—including modelled and historical bills-based approaches—are compared.

With hybrid systems, controls matter

With hybrid ducted heat pumps, installers must program the thermostat to control when the heating system switches from using a heat pump to using the fuel-based heating system. Two typical approaches exist: letting the heat pump run until it can no longer maintain the thermostat's temperature setpoint, at which point the fuelled system is activated, or programming a predetermined outdoor switchover temperature. NRCan's sizing guide and app provide two options for setting predetermined switchover temperatures:

1. **Thermal crossover point:** based on the theoretical outdoor temperature at which the heat pump no longer has the capacity to meet a home's heating needs, based on an assessment of the home's heating load as well as the specific heat pump model's capacity curves, or
2. **Economic crossover point:** the temperature where the operational cost of the heat pump becomes higher than the fuelled system.

Tools such as ThermalPoint can help users identify the thermal crossover point based on downloaded performance specs of the heat pump. We are not aware of any simple tool to determine the economic crossover point, but NRCan's heat pump sizing guide includes a detailed appendix that explains a methodology.

Using the economic crossover temperature to set default controls may be a poor long-term strategy. This is because homeowners are unlikely to reassess the economic crossover point every time utility rates change and because there will be multiple crossover temperatures if using time-of-use rates. **Because utility rates (both gas and electric) can change every few months, the initial crossover point will likely be misaligned with the economic reality for the vast majority of the heat pump's lifetime.**

In practice, we heard that many installers set the crossover point above freezing due to a lack of confidence in the effectiveness of the technology, regardless of the utility costs or the efficiency of modern cold climate heat pumps at low temperatures. We have also learned that some installers use default manufacturer settings that are not optimized to the home or geography, resulting in reduced efficiency and comfort complaints.[7]

The energy and emissions impacts of sizing and programming strategies

Different sizing and programming strategies can have very significant impacts on the total energy and emissions savings (see Table 1; noting we will explore the economic impacts in an upcoming report). Outcomes will differ by region based on heating loads and the grid's current and forecasted emissions intensity. In nearly all provinces, there are significantly greater energy and emissions reductions when heat pumps provide all or most of the heating. The exception is in Alberta and Saskatchewan where, due to the cold temperatures and still-heavy reliance on fossil fuels for electricity generation, building emissions can increase with heat pump adoption in the near term. While energy and emissions savings are greater when heat pumps are sized to cover all of the heating load, efforts should be made to avoid oversizing for cooling or sizing beyond the existing ductwork capacity. In places that regularly see very cold temperatures (e.g. Winnipeg, Saskatoon), sizing air-source heat pumps to provide all of, which can reduce overall efficiency.[8] More research could help optimize heat pump sizing in these regions. Programs that promote heat pumps with the goal of saving energy and emissions should be mindful of energy and emissions impacts of sizing heat pumps for hybrid programming.

Table 1: Using a Toronto home example, we see that how a heat pump is sized and programmed impacts the energy and emissions of the heating system relative to heating with a natural gas furnace.

NRCan sizing guide approach*	Sizing A	Sizing B	Sizing C	Sizing D
Heat pump sizing basis	80% of cooling load	125% of cooling load	Heating load at −8.3°C	Heating load at design temperature (-18°C)
Energy savings	9%	41%	56%	63%
Emissions reduction	15%	59%	83%	93%

* Assumes the ductwork can accommodate the sizes used here.

7 https://illumeadvising.com/2025/installation-is-the-innovation-unlocking-heat-pump-performance/

8 Efficiency Manitoba has incentives to help homeowners install ground-source heat pumps that can operate efficiently at all outdoor temperatures.

RECOMMENDATIONS

Recommendation 1

When possible, heat pumps should be sized based on historical heating energy use, and validated tools should be developed to support this

Modelled heating loads are designed to be conservative and will often include buffers that further increase their estimates as cover against unknown factors. Oversizing is common with fuelled heating systems since the impacts are minimal, but with modern heat pumps, oversized capacities can leave customers dissatisfied with costs, performance, and reliability.

Yet existing homes do not need someone to guess the theoretical performance of each envelope component to use in a model, since the whole home's thermal performance has already been empirically proven through existing energy bills. A home's historical energy use is the fastest and most accurate way to estimate heating loads.

Simple tools available today can help installers size the equipment based on the home's empirical energy use. However, the approach and these tools need to be validated if they are going to be trusted and used more broadly. Because run-time data recorded by smart thermostats offer an accurate practical estimate of actual peak loads—reflecting real-world performance under peak conditions—they could serve as the benchmark in controlled studies, with behavioural effects such as morning ramp-ups and open windows accounted for.

It is important for NRCan to recognize empirical approaches as a valid and preferred option for sizing heat pumps in existing homes because incentive programs are increasingly requiring the use of NRCan's heat pump sizing guide or app. NRCan is well placed to add historical energy use as the default method of estimating heating loads to its sizing guide and app. Heat pump incentive programs can also require sizing based on historical energy use where possible.

Updating The CSA F280 Standard to Recognize Empirical Methods

NRCan is already pursuing further research with CSA that could lead to expanding the F280 Standard by formally recognizing empirical methods for calculating heating loads in existing homes.

While traditional modelled approaches have gained traction in new construction, they are often too costly and time-consuming for retrofit projects, where contractors must respond quickly and seldom have access to detailed building data. Empirical methods, which rely on measured energy-use data such as utility bills, could offer a faster, lower-cost, and often more accurate alternative for sizing equipment in retrofit conditions.

To build confidence in this approach, NRCan is looking to work with software providers and researchers to test and validate empirical methodologies before potentially integrating them into the revised CSA F280 standard.

Recommendation 2

When building tools, developers must engage the HVAC industry to ensure the tools are useful to them in better sizing heat pumps

Installers need to be able to provide quotes to customers for heat pumps after only a brief walkthrough of the home. Sizing based on historical energy use would require installers to collect only two key data points: historical heating energy use and measurements of the cross-sectional area of the supply trunk(s) near the air handler. However, many installers may be reluctant to change their practices unless they clearly understand the added value it offers them.

The adoption of new heat pump sizing practices is best led by the HVAC industry and supported through incentive programs (e.g., by requiring the use of NRCan's heat pump sizing guide or app). Simple Canadian tools are available today to help installers size equipment based on empirical energy use (e.g., KnowYourLoad.ca), and many utilities provide historical energy use online (e.g., Green Button).

The industry should be engaged to understand what tools already exist and how they can be improved, how they can be supported in adopting them, and what other roadblocks may hamper their adoption. Mandatory training and certifications can support best practices.

Recommendation 3

Thermostat manufacturers should work with utilities to make it easier to configure and adjust control strategies and simplify access to data

Determining and programming the optimal control strategy for hybrid systems can be challenging for installers and customers alike, and homeowners are unlikely to change it in the future as energy prices evolve.

Heat pump and thermostat manufacturers must be encouraged to revisit and simplify hybrid heat pump programming. Homeowners and installers need simple tools to determine, program, and update hybrid system controls based on customer preference (e.g., lowest bills, lowest emissions, highest comfort).

As smart appliances become more common, it should be possible to calculate thermal and economic crossover points and even adjust the programming automatically as utility rates change. Utilities can support this move by making total variable cost per unit energy easier to access (e.g. in Ontario, costs are broken down by line item but not reported as a total cost per kWh or m3 natural gas). Relatedly, utilities and thermostat manufacturers should collaborate to facilitate the use of control strategies that take advantage of time-of-use (TOU) rates or critical peak pricing with hybrid heating systems.

Finally, modern thermostats should make it easier to access sizing-relevant data based on historical use and equipment run-time during hot and cold events.

Recommendation 4

Incentive providers should emphasize optimal heat pump sizing and programming

Heat pump incentives are currently based largely on heating equipment efficiency, yet real-world system performance also depends on how well a heat pump is sized and programmed. Poorly sized heat pumps and poor control strategies risk performance issues and customer dissatisfaction, as well as reduced energy and emissions impacts that undermine the effectiveness of the incentive program.

Ontario's Home Renovation Savings Program recognized the need for better heat pump sizing and now requires the use of NRCan's Air-Source Heat Pump Sizing and Selection App. However, this app recommends the use of modeled heating loads which often overestimate actual loads, and their incentives amounts are based on heat pump size, which encourages oversizing to access larger grants. Furthermore, experienced installers have noted that the app can be gamed to achieve a desired size.

There are many examples of programs considering or implementing quality installation requirements, including:

- The Rocky Mountain Institute recommending the incentive focus on heating system efficiency rather than size (i.e., the efficiency of the heat pump plus backup, which ensures heat pumps are programmed to minimize use of the backup) and that programs should focus on contractors instead of customers, including market development support.[9]
- Efficiency Maine's checklist to ensure installers assess heating loads when sizing systems, which provides links to approved heating load assessment tools.[10]
- BC Hydro's list of contractors who are qualified to size and install heat pumps.[11]

We recommend that heat pump incentive programs engage with installers and work together to include measures to ensure that the:

1. Installed equipment has high rated efficiencies,
2. Equipment is installed and commissioned according to industry best practices,
3. Equipment is sized based on historical energy use, and
4. Hybrid systems are programmed to ensure economic savings while also optimizing energy and emissions reductions.

Ideally incentives would include mechanisms to pay installers to take the time to properly commission each heat pump and submit documentation. Incentive programs could also

9 https://rmi.org/reforming-energy-efficiency-programs-to-increase-heat-pump-adoption/#endnotes

10 https://www.efficiencymaine.com/at-home/residential-heat-pump-incentives/

11 https://www.bchydro.com/powersmart/residential/rebates-programs/home-renovation/finding-qualified-contractors-and-advisors.html

require or recommend the use of qualified installers that have undergone additional training and/or certifications (e.g. HRAI Heat pump champion advocate). Incentive values should not be solely based on the size of the heat pump system, as this can encourage oversizing.

Accelerated heat pump adoption will also require new policies to improve their lifetime economics compared to natural gas, the fossil fuel used in nearly 45% of Canada's homes. This will be the focus of a future report.

Conclusion

The remarkable efficiencies of heat pumps and their ability to run on low-carbon electricity mean that heat pump adoption is our best tool for decarbonizing Canada's residential buildings. Yet those energy efficiency and emissions outcomes can be hampered by poor sizing and programming practices.

Current industry practices, often relying on outdated rules of thumb or overly conservative models, can result in oversized systems that compromise performance, increase costs, and erode public trust. Additionally, hybrid heat pumps may be programmed in ways that prioritize heating from fuelled systems over the more efficient and lower-carbon heat pumps.

We therefore recommend developing and promoting tools to support installers in using modern, best-in-class industry practices: using historical heating energy use for sizing and improving hybrid system programming.

These can be supported by requirements in incentive programs and complementary policies that improve the economic outcomes for operating heat pumps relative to conventional fuel-based equipment. A future report will explore the economics of operating heat pumps across the country and options available to make heat pumps more economically attractive.

These measures would ensure that heat pumps fulfill their promise—not only as a climate solution, but as a dependable, comfortable, and cost-effective technology for Canadian homeowners.